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UTILITY APPLICATION FOR UNITED STATES PATENT

FOR

**LITHIUM SECONDARY BATTERY**

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## LITHIUM SECONDARY BATTERY

### CROSS REFERENCE TO RELATED APPLICATION

This application is based on applications Nos. 99-2257 and 99-51148 respectively filed in the Korean Industrial Property Office on January 25, 1999 and November 17, 1999, the contents of which are incorporated hereinto by reference.

### BACKGROUND OF THE INVENTION

#### **(a) Field of the Invention**

The present invention relates to a lithium secondary battery and, more particularly, to a lithium secondary battery which exhibits particular mechanical properties using a thin negative current collector.

#### **(b) Description of the Related Art**

Conventionally, a copper foil with at least 99.8% purity has been used as a negative current collector for a lithium secondary battery. During charge and discharge, a negative electrode is expanded (an expansion of about 10%) and the expansion results in a tensile stress in a current collector made of the copper foil. However, as the durable tensile strength of copper foil is low, such a foil is easily torn.

The weak tensile strength of copper foil makes it difficult to reduce the thickness of the copper foil, which prohibits an increase in an amount of a negative active material in a battery. Accordingly, it is impossible to produce a battery having high capacity using copper foil.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a lithium secondary battery exhibiting good tensile strength.

It is another object to provide a lithium secondary battery using a thin negative current collector.

These and other objects may be achieved by a lithium secondary battery including a positive electrode formed by coating lithium metal oxides on a positive current collector, and a negative electrode formed by coating carbonaceous materials or  $\text{SnO}_2$  on a negative current collector. The negative current collector is made of a Cu-based alloy foil with a thickness of  $20 \mu\text{m}$  or less and the Cu-based alloy foil includes at least one material selected from the group consisting of nickel, titanium, magnesium, tin, zinc, boron, chromium, manganese, silicone, cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous, bismuth, lead, silver, and misch metal. The lithium secondary battery further includes a separator interposed between the positive and negative electrodes and an electrolyte into which the positive and negative electrodes and the separator are immersed.

## DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a lithium secondary battery exhibiting high capacity. The lithium secondary battery is manufactured by using a Cu-based alloy foil having both a good tensile strength and a thin thickness.

The Cu-based alloy foil includes at least one material selected from nickel, titanium, magnesium, tin, zinc, boron, chromium, manganese, silicone,

5 cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous bismuth, lead, silver and misch metal. The amount of nickel is 0.8 to 4 wt% of the copper, that of titanium is 0.2 to 4 wt% of the copper, that of magnesium is 0.05 to 0.6 wt% of the copper, and that of tin is 0.1 to 2.0 wt% of the copper. The amount of zinc is 0.0005 to 0.5 wt% of the copper, that of boron is 0.0005 to 5.0 wt% of the copper, that of chromium is 0.0005 to 0.5 wt% of the copper, and that of manganese is 0.1 to 1.0 wt% of the copper. The amount of silicone is 0.1 to 0.5 wt% of the copper, that of iron or cobalt is 0.01 to 2.0 wt% of the copper, that of vanadium is 0.0005 to 0.5 wt% of the copper, and that of aluminum is 0.005 to 0.5 wt% of the copper. The amount of zirconium is 0.0005 to 0.5 wt% of the copper, that of niobium is 0.0005 to 0.5 wt% of the copper, that of phosphorous is 0.02 to 0.16 wt% of the copper, that of bismuth is 0.0005 to 0.5 wt% of the copper, that of lead is 0.0005 to 0.5 wt% of the copper, and that of silver is 0.0005 to 0.5 wt% of the copper. If the materials are out of this range, it is <sup>difficult</sup> ~~difficult~~ to obtain a foil having the desirable tensile strength.

10 The Cu-based alloy foil is generally produced by an electro-plating ~~process~~ or a cold-rolling process.

20 In the battery of the present invention, the positive electrode may be produced by dissolving lithium metal oxides such as  $\text{LiCoO}_2$ ,  $\text{LiNiO}_2$ ,  $\text{LiMnO}_2$ ,  $\text{LiMn}_2\text{O}_4$  and a polyvinylidene fluoride binder in N-methyl pyrrolidone to make a slurry, coating the slurry on a positive collector made of aluminum foil, and drying the coated collector.

15 The negative electrode may be produced by dissolving an active

material into or from which lithium ions are intercalated or deintercalated (i. e. carbonaceous materials such as crystalline carbon or amorphous carbon, or  $\text{SnO}_2$ ) and a polyvinylidene binder in N-methyl pyrrolidone to make a slurry. The slurry is coated on a negative collector of the present invention and then dried. The negative collector preferably has a thickness of 20  $\mu\text{m}$  or less and the Cu-based alloy foil with about 15  $\mu\text{m}$  of thickness can be used for the collector without the deterioration of mechanical properties, such as its tensile strength.

The separator may be a porous film made of polyethylene or polypropylene.

The electrolyte may be a 1M solution prepared by dissolving  $\text{LiPF}_6$ ,  $\text{LiAsF}_6$ ,  $\text{LiCF}_3\text{SO}_3$ ,  $\text{LiN}(\text{CF}_3\text{SO}_2)_3$ ,  $\text{LiBF}_6$ , or  $\text{LiClO}_4$  in an organic solvent. The organic solvent may be of cyclic carbonates such as propylene carbonate or ethylene carbonate, linear carbonates such as dimethyl carbonate, or diethyl carbonate, or a mixture thereof.

The following examples further illustrate the present invention.

#### Examples 1 to 4 and Comparative Examples 1 to 2

Foil types for negative current collectors were manufactured according to the compositions shown in Table 1. The electrolytic copper foil was used in Comparative example 1 and the rolled copper foil was used in Comparative example 2. The tensile strengths thereof were measured and the results are present in Table 1. In Table 1, "Com." refers to "comparative example".

Table 1

|           | Composition  | Tensile strength [N/mm <sup>2</sup> ] |
|-----------|--|---------------------------------------|
| Example 1 | Ni: 1.8 wt%, Ti: 1.1 wt%, Cu: balance                                | 560                                   |
| Example 2 | Ni: 2.0 wt%, Ti: 0.9 wt%, Mg: 0.13 wt%,<br>Cu: balance               | 620                                   |
| Example 3 | Ni: 2.0 wt%, Ti: 1.1 wt%, Mg: 0.29wt%,<br>Mn: 0.52 wt%, Cu: balance  | 620                                   |
| Example 4 | Ni: 1.5 wt%, Ti: 0.9 wt%, Mg: 0.26 wt%,<br>Zn: 0.20 wt%, Cu: balance | 630                                   |
| Comp. 1   | Cu: at least 99.9 wt%  | 420                                   |
| Comp. 2   | Cu: at least 99.9 wt%  | 340                                   |

As shown in Table 1, the collectors of Examples 1 to 4 have superior tensile strength to those of Comparative Examples 1 to 2. The collector of Example 4 having 1.5 wt% of nickel, 0.9 wt% of titanium, 0.26 wt% of magnesium, and 0.20 wt% of zinc has the highest tensile strength.

As described, the present invention provides a negative current collector exhibiting improved mechanical strength and thermal conductivity by adding materials such as nickel or titanium to copper. The negative current collector of the present invention exhibits good tensile strength such that a wide collector can be produced to improve workability, and the thickness of current collector can be reduced to increase the capacity of the battery.

While the present invention has been described in detail with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention as set forth in the appended claims.